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Experiment analysis of EDM Processes parameters for Turning of EN31 automobile Bearing Steel materials Using Tool Rotation

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Abstract--- Electrical Discharge Machine is commonly used non-traditional machining process to machine high strength advance materials which are difficult to machine. The present research investigates the effect of tool rotating speed to the responses viz. MRR, TWR and surface roughness (Ra) of Electric Discharge Machine (EDM) processes viz. EDM, Dry-EDM, Near Dry EDM which used the liquid, gas and liquid-gas dielectric respectively. It is found that the increased in tool rotating speed increases MRR then decreases. It is also found that increase in tool rotating speed decreases Surface roughness (Ra). TWR for Dry-EDM and ND-EDM compared to Wet EDM is negligible..

Keywords--- EDM, Dry EDM, ND-EDM, Tool Rotation Speed, MRR, TWR, Ra

I. Introduction and Literature Review

Electrical discharge machining (EDM) is a commonly used non-traditional machining process to produce dies, molds, automotive industry and also surgical components [1]. It was first developed in the late 1940s [2] where material removal is done by series of electrical discharges between tool and the work piece within a dielectric medium [3]. EDM does not make any direct contact between the electrode and the work piece that can eliminate mechanical stresses and vibration problems. In EDM process, electrical energy is converted into thermal energy that creates plasma channel of temperature 8000- 12000˚C between the tool and workpiece which is
sufficient to melt the workpiece and the tool. The plasma channel spreads and causes and jumping out of the molten materials are jumping out from the workpiece and tool surfaces when a sudden drop in temperature by cutting off the pulse energy. The erosive effect of the electrical discharges is the key role to remove material from the In dry EDM, high-pressure air or gas such as air, oxygen, helium, nitrogen, and argon is supplied through the hollow tool electrode as a dielectric fluid [5]. The gas is injected inside the tool electrode with high pressure, which removes melted material from the working gap and cools down the tool electrode and the work piece. The role of the gas is to withstand as insulator and remove the debris between tool and work piece. It also use as a coolant for tool and work piece. However, low stability of arc column as compared to wet EDM is the Dry EDM process limitation [6]. First investigation of ND-EDM was carried out by Tambura et al. in 1989 [7]. The near-dry EDM process used a liquid dielectric is replaced by a mixture of gas and liquid dielectric. In 2007, Kao et al. was carried a meaningful investigation to study the effects of the electrode material and dielectric medium for roughing and finishing operations after first investigation. The dielectric is flushing through the hollow tool at high speed on the work piece surface [8]. In the present investigation, effect of tool rotating speed to the responses viz. MRR, TWR and Ra of Wet EDM, Dry EDM and ND-EDM were studied.

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NOMENCLATURE

N	Tool Rotating Speed (rpm)
MRR	Material Removal Rate (mm^3/min)
TWR	Tool Wear Rate (mm^3/min)
Ra	Arithmetical mean surface roughness (μm)

II. Experimental Setup

The experiment was investigated using Savita ZNC EDM having tool rotating attachments. An air compressor is used to supply compressed air between the electrodes gap for Dry EDM. The Near dry minimal quantity lubrication (MQL) device is used to develop two phase liquid and gas mixture for the ND-EDM. Experiment was conducted by using copper as electrode and EN31.

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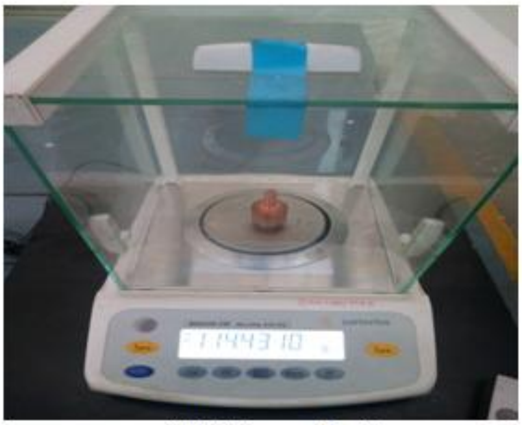
Exp Run Order	PC	Trpm	Sa	TWR	MRR
1	8	1200	60	0.03	0.14315
2	8	1200	80	0.0252	0.18885
3	8	1200	100	0.0272	0.20055
4	8	1500	60	0.02205	0.10195
5	8	1500	80	0.0146	0.14175
6	8	1500	100	0.04435	0.19135
7	8	1800	60	0.037	0.2274
8	8	1800	80	0.0392	0.1262
9	8	1800	100	0.03275	0.1748
10	10	1200	60	0.03585	0.0896
11	10	1200	80	0.04195	0.1482
12	10	1200	100	0.0667	0.1472
13	10	1500	60	0.0541	0.1024
14	10	1500	80	0.06655	0.24965
15	10	1500	100	0.05765	0.1267
16	10	1800	60	0.06575	0.14455
17	10	1800	80	0.06915	0.1904
18	10	1800	100	0.0626	0.1279
19	12	1200	60	0.07575	0.1793
20	12	1200	80	0.0921	0.25965
21	12	1200	100	0.0961	0.24525
22	12	1500	60	0.0813	0.17975
23	12	1500	80	0.094	0.23775
24	12	1500	100	0.0892	0.2162
25	12	1800	60	0.0801	0.16655
26	12	1800	80	0.0833	0.15805
27	12	1800	100	0.1014	0.1997

(EDM With rool rotation)

In EDM, the dielectric fluid also performs the function of a coolant medium and reduces the extremely high temperatures in the arc gap. More importantly, the dielectric fluid is pumped through the arc gap to flush away the eroded particles between the workpiece and the electrode. Proper flushing is critical to high metal removal rates and good machining conditions

Each discharge melts or vaporizes a small area of the workpiece surface. Thismolten metal is then cooled in the dielectric fluid and solidifies into a small spherical particle (swarf) which is then flushed away by pressure



(Weighing machine)

The impact of each pulse is confined to a very localized area, the location of which is determined by the form and position of the electrode. Both the workpiece and electrode are submerged in a dielectric fluid which acts as an electrical insulator to help control the spark discharges. It consists of an electrode and the workpiece submerged in an insulating liquid such as oil or other dielectric fluids. The electrode and workpiece are connected to a suitable power supply. The power supply generates an electrical potential between the two parts. As the electrode approaches the workpiece, dielectric breakdown occurs in the fluid, forming a plasma channel, and a small spark jumps.These sparks usually strike one at a time.

III.Result and discussion

Discharge current (current Ip): Current is measured in amp allowed per cycle. Discharge current indirectly proportional to the Material removal rate. Duty cycle (τ): It is a percentage of the on-time relative to the total cycle time. This parameter is calculated by dividing the on-time by the total cycle time (on-time pulse off time). T = Ton /Ton + T off Voltage (V): It is a potential that can be measure by volt it is also effect to the material removal rated and allowed to per cycle. Over cut – It is a clearance per side between the electrode and the work piece after the marching operation. Wire EDM Machining is also known as Spark EDM. It is an electro thermal production process in which a thin single-strand metal wire (usually brass) in conjunction with de-ionized water which is used to conduct electricity allows the wire to cut

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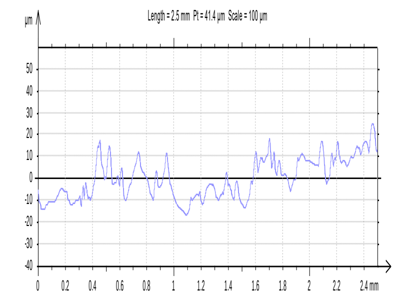
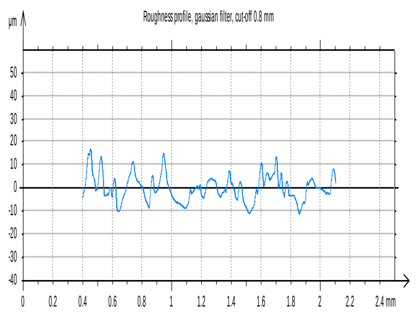
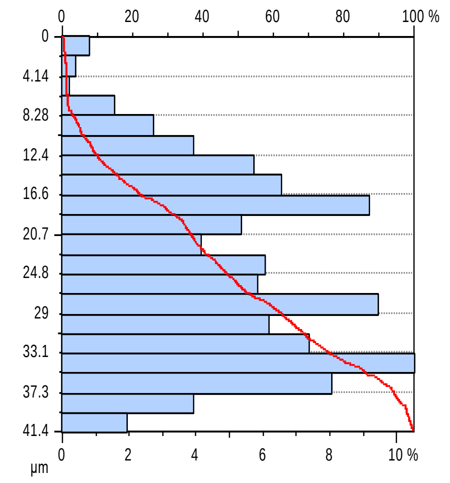
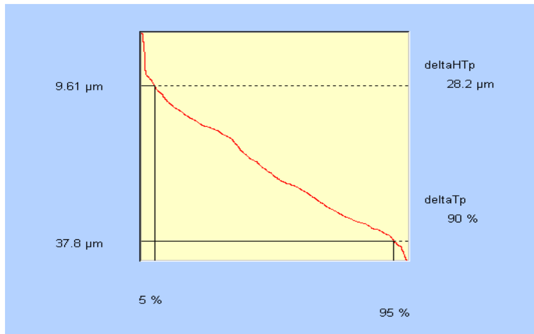
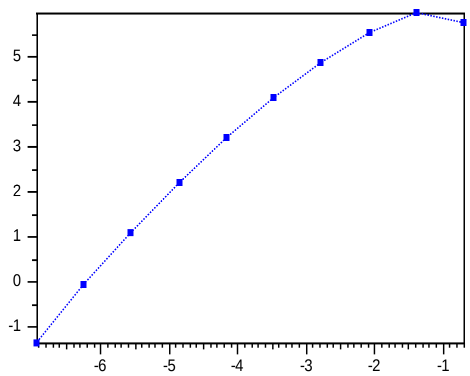
through metal by the use of heat from electrical sparks. Wire-cut EDM is typically used to cut plates as thick as 300mm and to make punches, tools, and dies from hard metals that are difficult to machine with other methods Wire-cutting EDM is commonly used where low residual stresses are desired, because it does not require high cutting forces for removal of material. If the energy/power per pulse is relatively low (as in finishing operations), little change in the mechanical properties of a material is expected
due to these low residual stresses, although material that hasn't been stress-relieved can distort in the machining
process. Due to the inherent properties of the process, wire EDM can easily machine complex parts and precision components out of hard conductive materials.
EDM system is comprised of four major components.
(1) Computerized Numerical Control (CNC): This act as "The Brains."
(2) Power Supply: Provides energy to the spark. This act as "The Muscle."
Mechanical Section: Worktable, work stand, taper unit, and wire drive mechanism. This is the actual machine tool. This act as "The Body."
(3) Dielectric System: The water reservoir where filtration, condition of the water resistivity/ conductivity and temperature of the water is provided and maintained. This act as "The Nourishment".



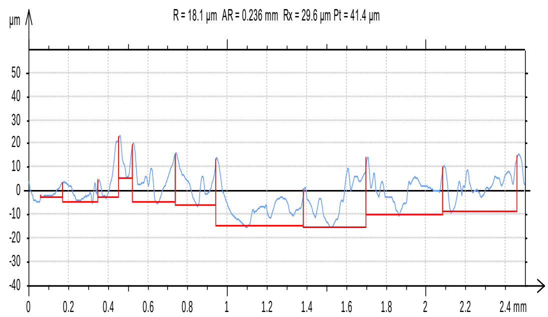


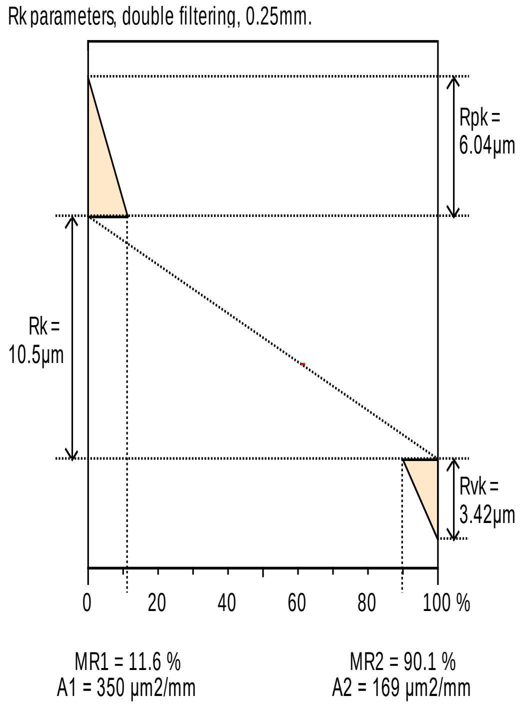


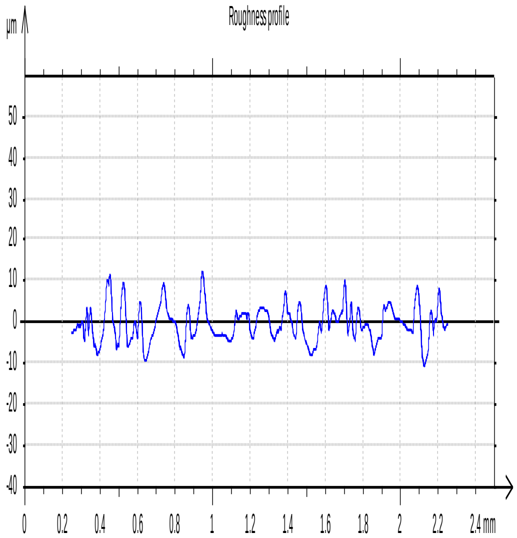


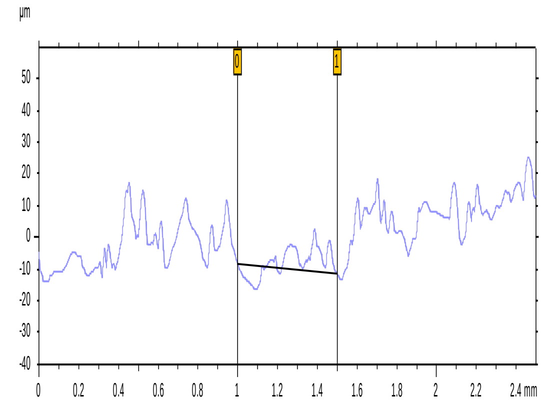


Fractal dimension: 1.26

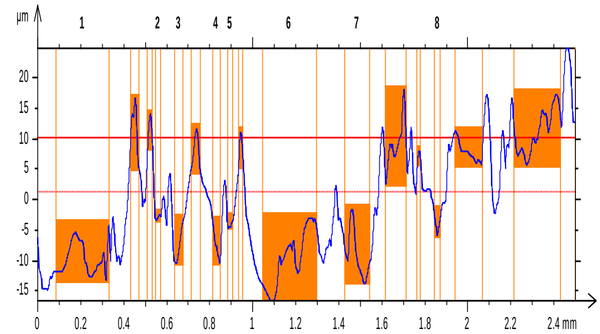




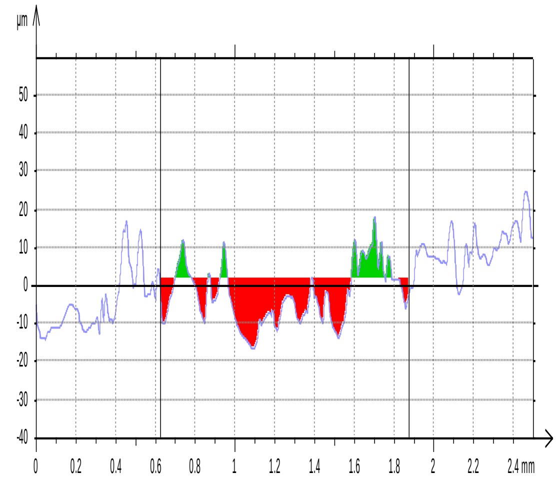




	0-1
Horizontal distance :	0.5 mm
Variation in height :	-3.09 µm



	1	2	3	4	5	6	7	8
Maximum depth	23 µm	13 µm	20.1 µm	20.1 µm	14.4 µm	26.7 µm	23.3 µm	15.7 µm
Mean depth	19.3 µm	12.7 µm	17.3 µm	17.5 µm	13.8 µm	19.3 µm	18.9 µm	14 µm
Width	0.251 mm	0.0225 mm	0.0415 mm	0.035 mm	0.0235 mm	0.249 mm	0.113 mm	0.0285 mm



Maximum depth :	19.3 µm	Area of the hole :	8288 µm2
Maximum height :	15.2 µm	Area outside :	1562 µm2

During normal operation the electrode never touches the work piece, but is separated by a small spark gap. During operation, the ram moves the electrode toward the work piece until the space between them is such that the voltage in the gap can ionize the dielectric fluid and allow an electrical discharge (spark) to pass from the electrode to the work piece. These spark discharges are pulsed on and off at a high frequency cycle and can repeat 250,000 times per second. The spark discharge (arc) always travels the shortest distance across the narrowest gap to the nearest or highest point on the workpiece. The amount of material removed from the workpiece with each pulse is directly proportional to its energy.

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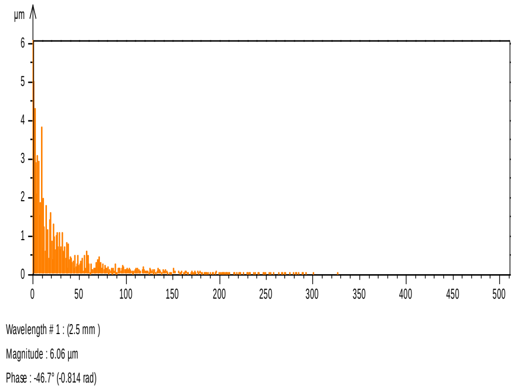

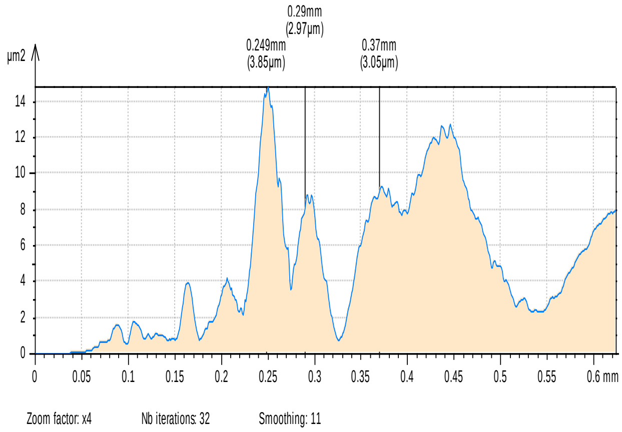

Parameters calculated on the profile Profile

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* Parameters calculated by mean of all the
sampling lengthes.
* A microroughness filtering is used, with a ratio
of 2.5 µm.

Roughness Parameters, Gaussian filter, 0.8 mm

  Ra     = 4.53 µm
  Rz     = 25.9 µm
  Rq     = 5.71 µm
  Rp     = 15.1 µm
  Rv     = 10.7 µm
  Rt     = 28.1 µm
  Rsk    = 0.392
  Rku    = 3.04
  Rmr    = 0.4 %     (1 µm under the highest peak)
  Rdc    = 8.69 µm   (20%-80%)
  RSm    = 0.121 mm
  RDq    = 21.6 °
  RLq    = 0.0952 mm
  RLo    = 6.3 %
  RzJIS  = 18 µm
  R3z    = 21.5 µm
  RPc    = 7.65 pks/mm        (+/- 0.5 µm)
  Rc     = 13 µm
```

Response table for EDM, Dry EDM and ND-EDM process

Run	Tool Rotating Speed	Wet EDM MRR	Wet EDM TWR	Wet EDM Ra	Dry EDM MRR	Dry EDM TWR	Dry EDM Ra	ND-EDM MRR	ND-EDM TWR	ND-EDM Ra
1	0	2.941	0.009	7.264	3.562	0.004	6.846	3.782	0.004	6.341
2	500	3.315	0.008	7.02	4.128	0.003	6.677	4.452	0.006	6.272
3	1000	2.632	0.012	6.195	3.386	0.004	5.866	4.562	0.004	5.567
4	1500	2.033	0.02	5.59	2.523	0.006	5.371	2.598	0.005	5.486
5	2000	1.311	0.025	5.22	1.345	0.006	5.148	1.354	0.005	5.026

C. Analysis of Ra

The effect of tool rotating speed to the surface roughness is shown in Figure 3. It can be concluded from the Figure 3 that Surface roughness (Ra) decreased with increased of the tool rotating speed. Surface the tool rotating speed. Surface roughness Ra value of Wet EDM, Dry EDM and ND-EDM were closed at the higher value of tool rotating speed. This can be occurred due to the effect of the pressurized gas which helps to remove melted material from the working gap and cools down the tool electrode and the workpiece.

IV. Conclusion

The effect of tool rotating speed to the responses viz. MRR, TWR and Ra for EDM processes viz. Wet EDM,Dry EDM and ND-EDM was carried. It can be concludedthat ND-EDM process has maximum MRR, negligibleTWR and minimum surface roughness from the WetEDM and Dry EDM process

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